National Aeronautics and Space Administration

NASA NEXT

EMPOWERING THE NEXT GENERATION OF SPACE EXPLORERS

OSIRIS-REx

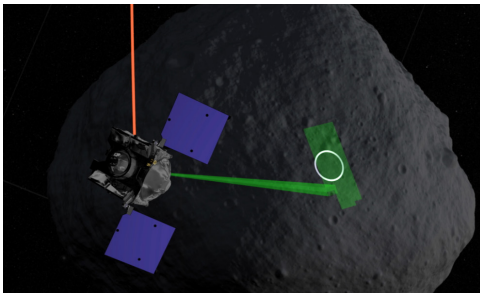
NASA's asteroid sampling mission takes off

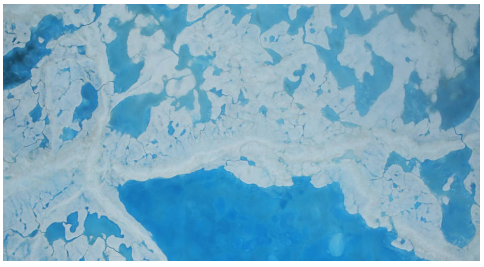
PAGE 6

www.nasa.gov

A meteor streaks across the sky during the annual Perseid meteor shower on Aug. 12, 2016, in West Virginia. What have you seen in the night sky? **NASA/Bill Ingalls**

SEPTEMBER 2016





DEAR READER,

Humans are curious; they love to explore. Throughout our history, man has tirelessly pursued the next horizon. The same is true of our scientists and engineers.

NASA's missions and accomplishments are a direct result of this inescapable curiosity and thirst for exploration. To many of our scientists and engineers, space is the final frontier — a place of endless discovery.

Our eyes are fixed on this frontier. NASA's Hubble Space Telescope has helped scientists uncover some of the most distant objects ever seen. We observed the Juno spacecraft make its arrival at Jupiter this summer. In fall, we watch as OSIRIS-REx travels to a near-Earth asteroid known as Bennu to retrieve a sample and send it back to Earth.

But our scientists and engineers know that we also must keep a close eye on our own planet. Warmer than average temperatures and disappearing sea ice are indicators that our planet is changing. NASA continuously monitors and studies these changes to help us understand the future of our home.

I hope this magazine inspires you to explore and make a great discovery all your own. You are our next generation of scientists and engineers, and it is through you that this pursuit of discovery will continue.

Sarah Schlieder
NASA Next editor

NASANEXT
EMPOWERING THE NEXT GENERATION OF SPACE EXPLORERS

Goddard Space Flight Center
Volume 1, Issue 2 | September 2016

Front cover: An illustration of OSIRIS-REx before sampling the near-Earth asteroid Bennu. **NASA/Goddard Space Flight Center/Conceptual Image Lab**

Back cover: An artist's concept of our sun 4 billion years ago. **NASA/Goddard Space Flight Center/Conceptual Image Lab**

juno meets a giant

NASA/JPL-Caltech

Jupiter has captivated people since ancient times. Today, scientists believe Jupiter holds clues to understanding our solar system's origins and formation.

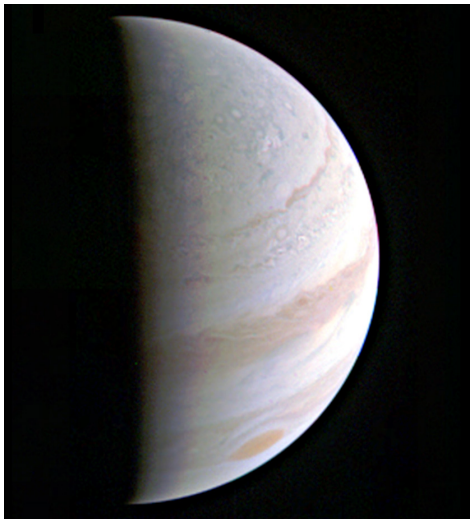
NASA's Juno spacecraft launched August 5, 2011, and traveled more than 2 billion miles to reach Jupiter. Juno, which arrived at Jupiter on July 4, will spend more than a year at the gas giant, orbiting Jupiter 37 times in total. The spacecraft will unravel some of the greatest mysteries surrounding Jupiter, including its origin, atmosphere and magnetosphere.

Jupiter is a ball of gas 11 times wider than Earth and 300 times more massive. It takes 12 years to orbit the sun, but it rotates so fast that its day is only 10 hours long. Its magnetic field is nearly 20,000 times as powerful as Earth's field, reaching as far as Saturn's orbit. If it were visible in the night sky, Jupiter's magnetic field would appear as large as the full moon.

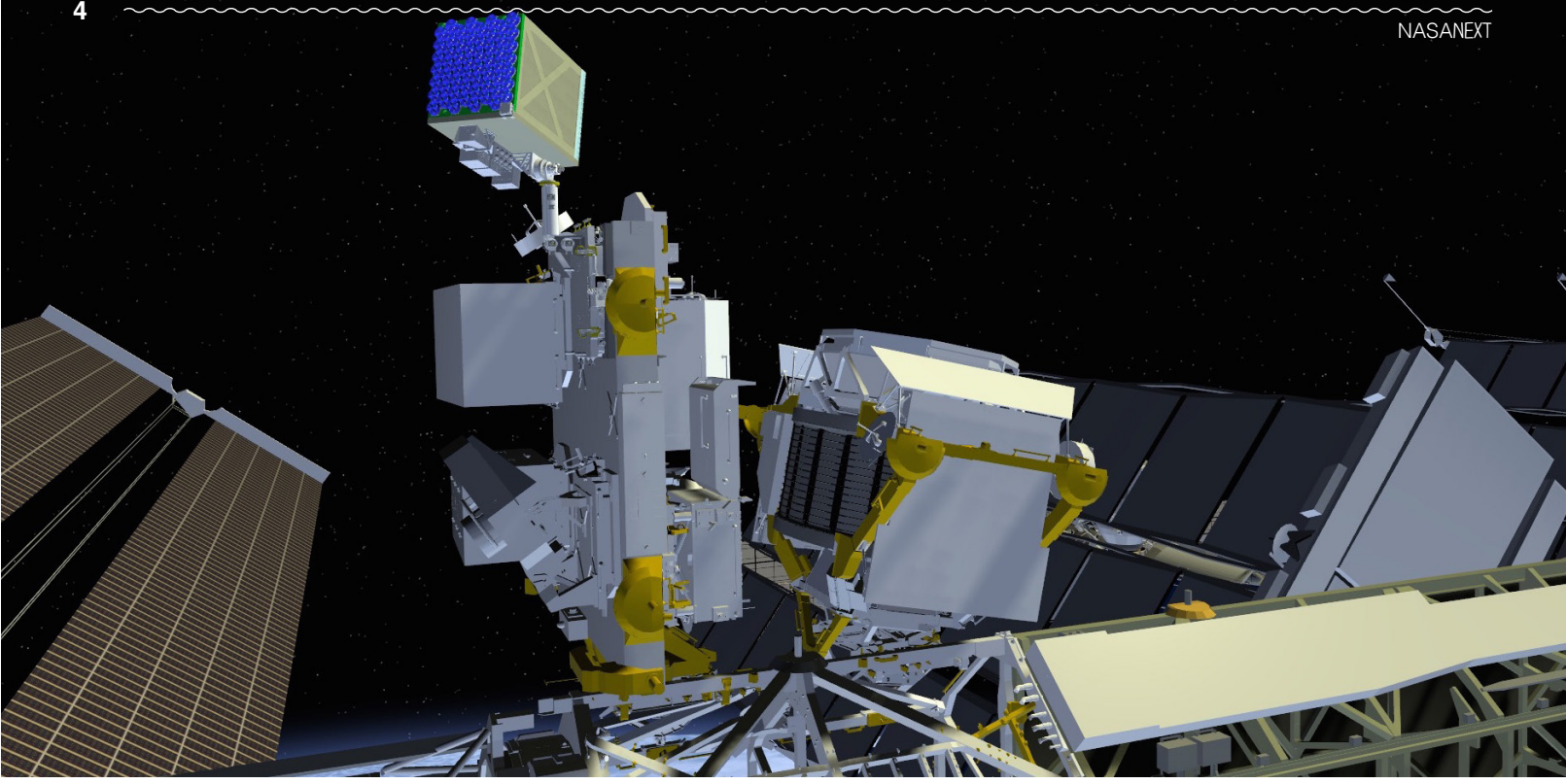
But scientists are unsure what exactly generates Jupiter's magnetic field. We know that magnetic fields are produced by dynamos. As a planet rotates, the liquid swirls around and drives electric currents, creating a magnetic field. Earth's magnetic field is generated by liquid iron in its core. But with Jupiter, scientists do not know what material is producing its magnetic field. Observations made by Juno will help to solve this mystery.

The team equipped Juno with a pair of magnetometers to look inside Jupiter and map its magnetic field. A magnetometer is like a compass. Both record the direction of a magnetic field. But magnetometers expand on that capability and record the direction and magnitude of the magnetic field.

By mapping Jupiter's magnetic field and peering inside the planet, scientists hope to gain a better understanding of what produces the giant's magnetic field.



Jupiter's north polar region comes into view as Juno passes the giant planet.
NASA/JPL-Caltech/SWRI/MSSS



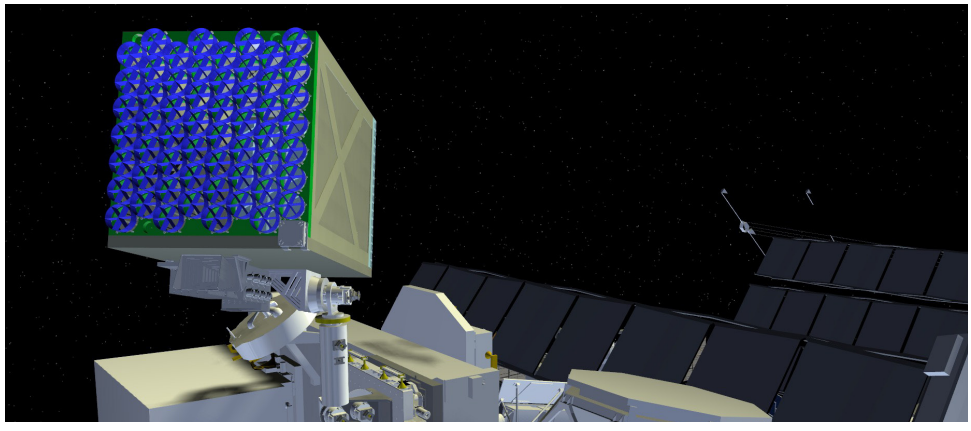
This artist's rendition shows the NICER payload. The mission will reveal the physics that make neutron stars the densest objects in nature. **NASA**

NASA MISSION PROFILE

Meet NICER

In 2017, a NASA mission will begin uncovering the physics surrounding the ultra-dense interiors of neutron stars. **NASA's Neutron star Interior Composition Explorer (NICER) mission** will uncover the physics surrounding the interiors of a particular group of stars known as neutron stars.

A neutron star begins its life as a star that has about 10 times the mass of the sun. When its nuclear fuel exhausts, the star's outer layers explode in a supernova. Crushed by its own gravity, the star's core collapses and forms what scientists call a neutron star. These stellar corpses are the densest, most magnetic and fastest spinning objects known in the universe.



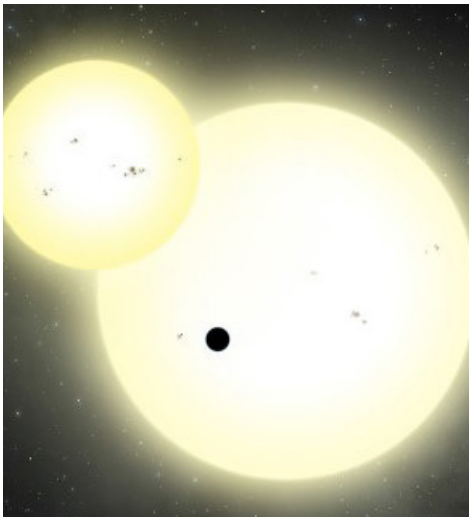
The 56-telescope payload will fly on the International Space Station. **NASA**

Some rapidly rotating neutron stars, called pulsars, are like cosmic lighthouses that sweep narrow beams of radiation through space as they spin. They can spin up to hundreds of times every second. NICER will use these pulsations to investigate physics of the interiors of these stars, as well as demonstrate a technological first: spacecraft navigation using pulsars as beacons. This will ultimately further deep space exploration into the solar system and beyond.

Scientists have created models to describe the physics of neutron star interiors. Ultimately, NICER's astrophysical observations will test these models.

One planet, two suns

A planet orbiting two suns — sounds straight out of *Star Wars*, right? NASA scientists spot new Tatooine-like planet.



A team led by astronomers from NASA's Goddard Space Flight Center and San Diego State University in California discovered a new planet that orbits two suns — much like Luke Skywalker's home world in *Star Wars*.

Using data from NASA's **Kepler Space Telescope**, astronomers searched for slight dips in brightness that hint a planet might be passing in front of the stars, blocking a tiny amount of their light.

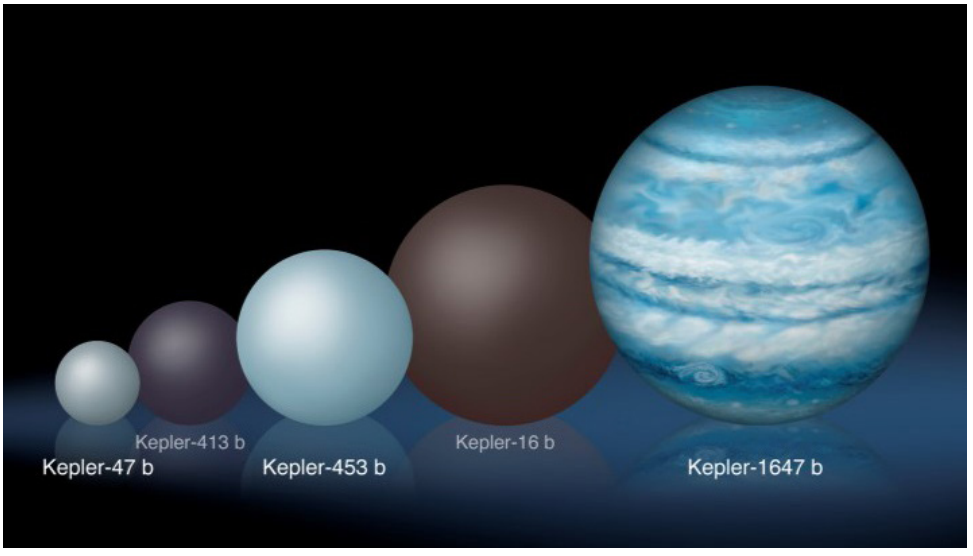
The planet, Kepler-1647b, is located in the constellation Cygnus. It is the largest planet yet discovered around a double-star system — that is, a planet orbiting two suns. It has a mass and radius nearly identical to that of Jupiter! Kepler-1647b takes 1,107 days — just over three years — to orbit both of its stars. It is about 3,700 light-years away and about 4.4 billion years old. That's roughly the same age as Earth!

Planets that orbit two stars are known as **circumbinary planets**, or sometimes "Tatooine," like in "Star Wars." The stars are similar to the sun, with one slightly larger than our own and the other slightly smaller.

WORDS TO KNOW

Circumbinary planet: a planet that orbits two stars

Kepler Space Telescope: Launched in 2009, this space observatory is searching for Earth-size planets orbiting other stars. So far, it's confirmed more than 2,330 exoplanets — and counting.



Left, an artist's impression of the stellar eclipse and planetary transit events on Kepler-1647b. Below, a comparison of the relative sizes of several Kepler circumbinary planets. Kepler-1647b is much larger than any of the previously discovered circumbinary planets. **Both illustrations: Lynette Cook**

DESTINATION: ASTEROID

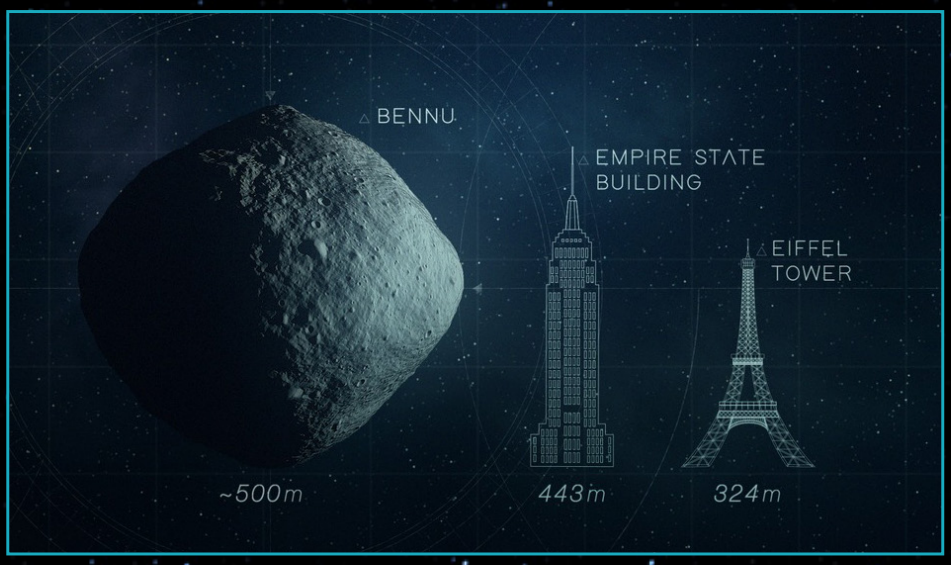
Launching this fall, NASA's OSIRIS-REx spacecraft will travel to the asteroid Bennu to collect a sample and bring it back to Earth for study. This is the first NASA mission of its kind!

OSIRIS-REx stands for Origins, Spectral Interpretation, Resource Identification, Security – Regolith Explorer. After launching on a rocket from Florida, the spacecraft will orbit the sun for a year, then use Earth's gravitational field to assist it in its journey toward the asteroid. OSIRIS-REx will begin its approach toward Bennu in 2018. It will then spend more than a year imaging and mapping the asteroid, as well as taking detailed measurements and observations.

Using the images, maps and data, the team will select a sample site in which OSIRIS-REx will briefly touch the surface of Bennu to retrieve a sample. The spacecraft will extend its long sampling arm and make contact with the asteroid for about five seconds, during which it will retrieve a sample of regolith — the loose material on the asteroid surface.

With sample in hand, OSIRIS-REx will begin its journey back to Earth in 2021, arriving two and a half years later in 2023. The sample — stowed in the sample return capsule — will separate from the spacecraft and enter the Earth's atmosphere and use a parachute to land safely on Earth.

Scientists from all over the world will be able to study the sample for years to come. Analyzing the sample will help us understand the early solar system. Asteroids are the remnants of the building blocks that formed the planets and enabled life. Some may contain natural resources such as water, organics and metals.



NASA/Goddard Space Flight Center

MEET BENNU

Near-Earth Asteroid 101955 **Bennu** is the target of the OSIRIS-REx mission. It was first discovered on Sep. 11, 1999, by the Lincoln Laboratory Near Earth Asteroid Research project, part of NASA's NEO Observations Program.

Bennu is the most well-understood near-Earth asteroid that has not been visited by a spacecraft. It has a diameter of about 1,614 feet (492 meters). It orbits the sun about every 1.2 Earth years.

Bennu's mass is estimated at 85.5 million U.S. tons (77.6 million metric tons).

Bennu was named by a third-grader as part of an international student contest. The asteroid was named after the Egyptian mythological figure linked to rebirth.

By returning a sample to Earth for study, scientists will better understand the formation of planets and our solar system, as well as the origin of life.

WHAT'S IN A NAME?

OSIRIS-REx is an acronym of the mission's objectives:

Origins
Return and analyze a pristine, carbon-rich asteroid sample

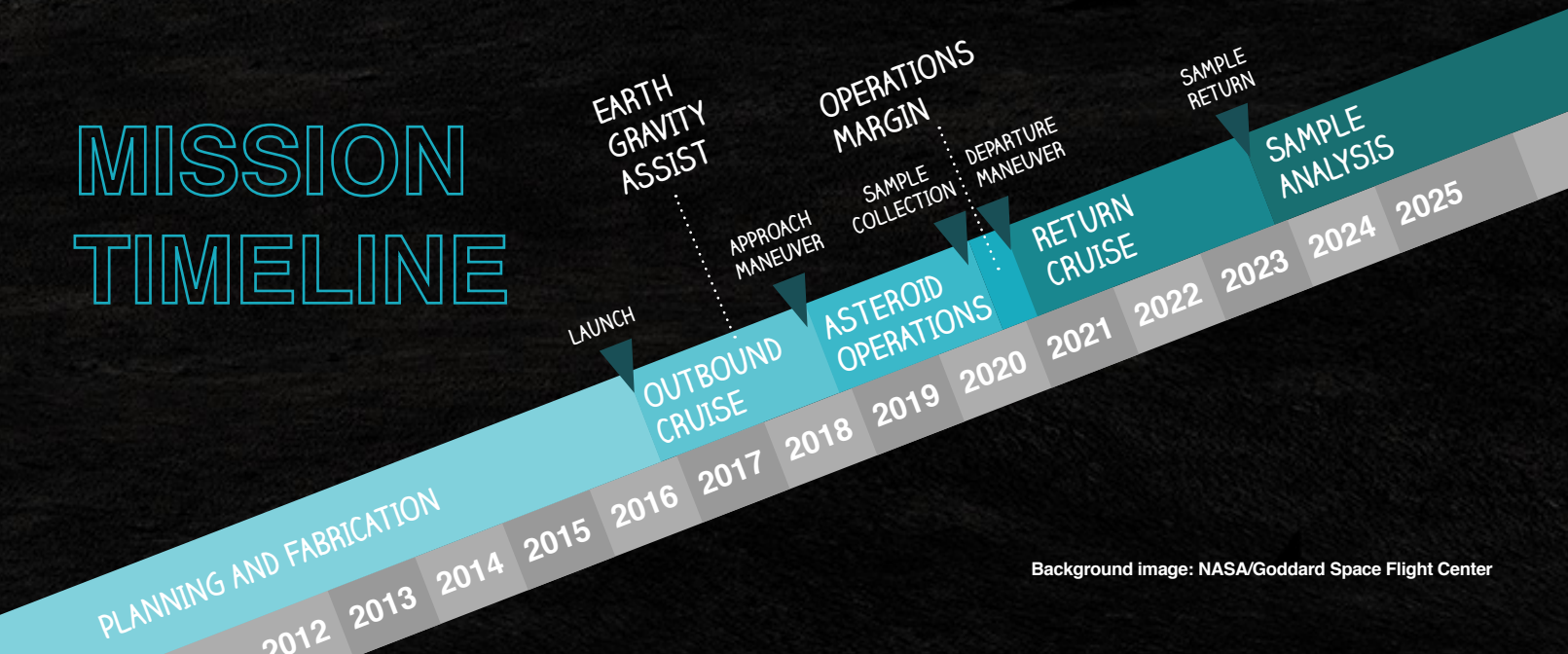
Spectral Interpretation
Provide direct observations for telescopic data of the entire asteroid

Resource Identification
Map the chemistry and mineralogy of a primitive carbon-rich asteroid

Security
Measure the effect of sunlight on the orbit of a small asteroid, known as the Yarkovsky effect — the slight push created when the asteroid absorbs sunlight and re-emits that energy as heat

Regolith Explorer
Document the regolith — layer of loose, outer material — at the sampling site

MISSION TIMELINE



Background image: NASA/Goddard Space Flight Center

Webb's sunshield catches some rays

The shiny silver material aboard NASA's James Webb Space Telescope may look like a giant sheet of tin foil, but it's actually a complex and innovative feat of science and engineering.

The telescope's five-layer sunshield is lightweight and robust to protect the telescope and its mirrors from the sun's radiation. Some of the things that make the sunshield unique are its strong yet ultra-thin material, special kite-like shape, and the special role of its layers.

MATERIAL MAKE-UP

The sunshield consists of five layers of a material called Kapton. Each layer is coated with aluminum. The sun-facing side of the two hottest layers also have a treated silicon coating to reflect the sun's heat back into space.

The sunshield is a critical part of the telescope because the infrared cameras and instruments aboard must be kept very cold and out of the sun's heat and light to work properly.

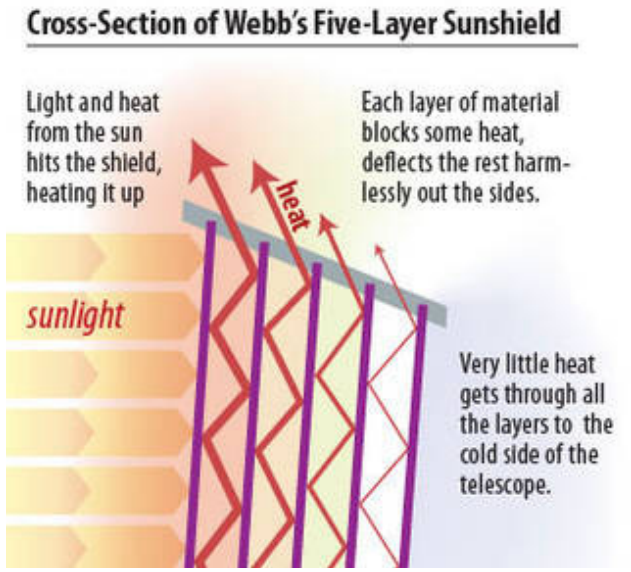
KITE-LIKE SHAPE AND LAYERS

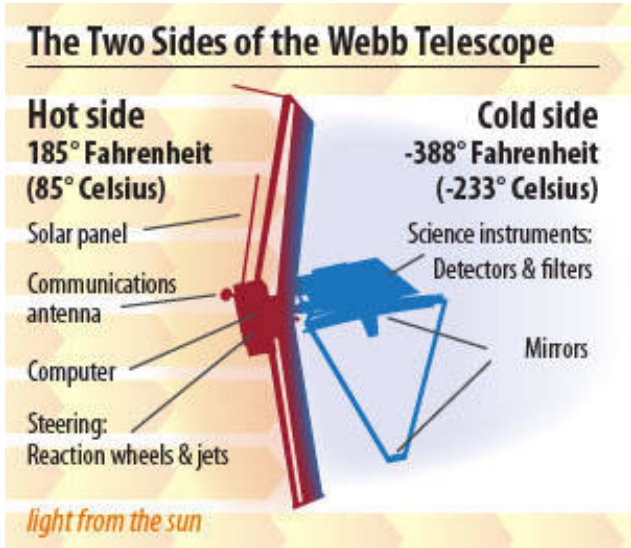
The kite-like shape and the number of layers of sunshield both play an important role on the Webb telescope. Each layer is made from a unique material, each has a specific thickness and size, and they all must be precisely separated in space.

The five layers block and re-direct heat to get the telescope down to required temperatures at which the instruments can operate. The gap between the layers provides an additional insulating effect.

The layers are slightly different sizes and shapes. Layer 5, which lies just under the primary mirror, is smallest and Layer 1 is largest. Layer 1 is relatively flat and Layer 5 is more curved.

The James Webb Space Telescope is the scientific successor to NASA's Hubble Space Telescope. It will be the most powerful space telescope ever built.





Both infographics: STScI

*Learn more about the James Webb Space Telescope and check out videos, photos and more at **jwst.nasa.gov**.*

Hubble looks to the final frontier

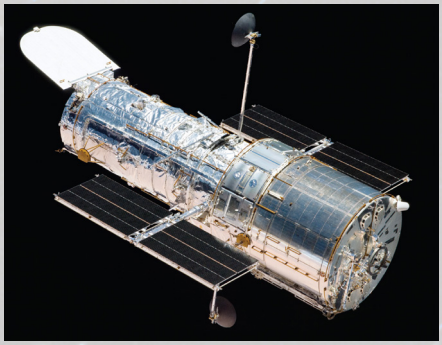
Just as *Star Trek* aimed to boldly go where no one has gone before, NASA's Hubble Space Telescope is boldly peering deeper into the universe than ever before.

Since 1990, Hubble has been helping scientists uncover some of the most distant objects ever seen.

This Hubble image unveils a cluttered-looking universe filled with galaxies near and far.

In the center of the image is the galaxy cluster Abell S1063, located 4 billion light-years away, and surrounded by magnified images of galaxies much farther away.

The cluster contains nearly 100 million-million solar masses and contains 51 confirmed galaxies and perhaps even 400 more.



Both images: NASA, ESA and J. Lotz (STScI)

THE MELTING ARCTIC

This image, taken from an Operation IceBridge flight over the Beaufort Sea on July 14, shows a large pool of melt water over sea ice. This summer, IceBridge mapped the extent, frequency and depth of melt ponds. **NASA/Operation IceBridge**

Arctic sea ice grows and shrinks throughout the year. It reaches its maximum between February and April, and hits its minimum in September during what is known as melt season, which occurs in the spring and summer.

This year's melt season in the Arctic Ocean began with a record low maximum in March and continued with relatively rapid ice loss of sea ice through the month of May.

Though the melt slowed down in June, the Arctic sea ice cover is not showing any signs of recovery. September Arctic sea ice — when sea ice is at its minimum — is now declining at a rate of 13.4 percent per decade compared to the 1981 to 2010 average.

To study these shrinking sea ice levels, a NASA airborne survey of polar ice carried research flights over Arctic sea ice this summer. Its target: aquamarine pools of water from melted sea ice on the sea ice surface that may be accelerating the overall melt.

To study shrinking sea ice levels, a NASA airborne survey of polar ice carried research flights over Arctic sea ice this summer. **NASA/Operation IceBridge**

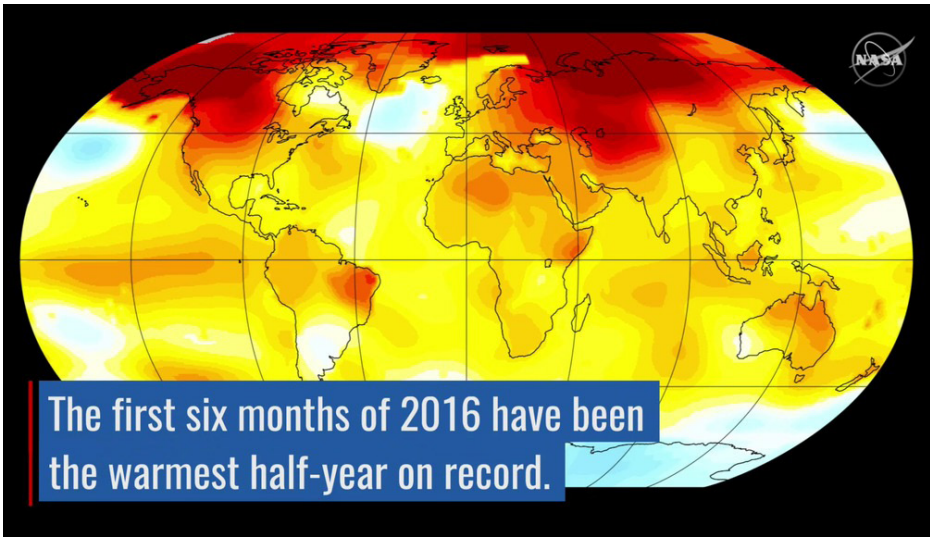
NASA's Operation IceBridge completed the first research flight of its new 2016 arctic summer campaign on July 13. The science continued through the end of July, collecting data on sea ice in a year following a record-warm winter in the Arctic.

The summer flights mapped the extent, frequency and depth of melt ponds, which are — the pools of melt water that form on sea ice during spring and summer. Studies have found that the formation of melt ponds early in the summer is a good predictor of the sea ice yearly minimum extent in September. Essentially, if there are more ponds on the ice earlier in the melt season, they reduce the ability of sea ice to reflect solar radiation. This leads to more melt.

The flight campaign operated from Barrow, Alaska. The flights are low at an altitude of 1,500 feet (450 meters). The plane carried three instruments that measured changes in the ice elevation and surface temperatures and created color maps of sea ice.

Heating Up

The first half of 2016 is the warmest half-year on record. What does that mean for our planet?



NASA/Goddard Space Flight Center/Matthew Radcliff

Global surface temperatures broke numerous records through the first half of 2016.

Each of the first six months of 2016 set a record as the warmest respective month globally in the modern temperature record, which dates back to 1880.

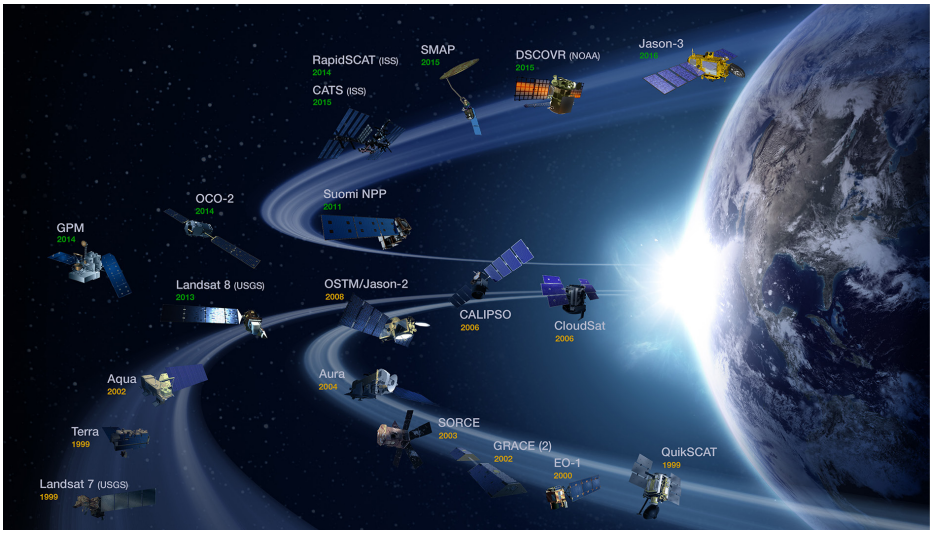
The six-month period from January to June was also the planet's warmest half-year on record, with an average temperature 1.3 degrees Celsius (2.4 degrees Fahrenheit) warmer than the late 1800s. July 2016 also set the record as the hottest month ever since 1880.

While this climate indicator has broken records in 2016, NASA scientists said it is more significant that global temperature is continuing its decades-long trend of change.

The trend is ultimately driven by rising concentrations of heat-trapping carbon dioxide and other greenhouse gases in the atmosphere.

NASA tracks temperature as part of its effort to understand the Earth as a system and to understand how Earth is changing.

In addition to maintaining 19 Earth-observing space missions, NASA also sends researchers around the globe to investigate different aspects of the planet at closer range.



NASA

DID YOU KNOW?

NASA has a fleet of satellites observing Earth's air, land and sea. The Earth Observing System (above) is helping scientists understand our planet as a whole. On the ground, in the air and in orbit, NASA is working to understand our changing climate.

If you could build and launch a satellite to orbit Earth, what would it study?

Q&A

Joy Ng // office of communications

Joy Ng translates science into videos that reach thousands of people. Her goal: share NASA's work with the world. Ng tells us how her interest in science and art let her to a job in science storytelling.

Copyright Nadine Ajaka. Used with permission.

JOY NG

Job: Mutimedia and social media fellow

Previous job: BBC Science Unit

What do you do at Goddard? How do you help support Goddard's mission?

I transform science research into videos understandable to non-experts. These videos appear on *NASA.gov*, YouTube and other social media platforms. I primarily focus on covering NASA's research within Earth science, which includes things like volcanoes, oceans, the atmosphere and climate.

Why did you become a science storyteller?

When I was younger, my teachers didn't know where I was headed. I was very artistic. I was also good in science and at one point thought I might become a scientist. During university, I realized that most scientists are very specialized and found that I was drawn to learning about everything. As well as choosing biology courses from human genetics to plant pathology, I also chose courses in Spanish and psychology. My love of learning and exploring science in a broader sense, led me to work in museums, radio stations and television. One of my first positions was with the BBC Science Unit in London, where I helped set up shoots, research topics and interview potential contributors. I then worked with other British TV production companies before starting my master's at Imperial.

I love getting people excited about the big and small quirks of science and have found telling stories is the best way to connect with people whether through writing, exhibitions, radio or video.

Why did you come to Goddard?

I wanted to come to Goddard for many reasons. I wanted to gain experience doing science communication in a different country. I also wanted to meet scientists from all over the world. Goddard has a huge role in studying the Earth, sun, solar system and universe and is very international. I was really excited about being in the middle of all the amazing work that goes on here. I still jump around with excitement when I chat to a scientist about a new finding or an animator about coming up with a new visualization.

What do you think about when making videos?

I always have the audience in mind when creating videos. I never make assumptions about what people know. I ask myself, "What will they find interesting? What can I link this to that is relevant to them? How can I keep them watching until the end of the video?" Sometimes I break down misconceptions to draw people into the video.

What do you say to yourself when thinking of new projects?

I always try to learn something new in the process, whether it is a new technical skill or trying to tell a story in a different way. Also, I always try to remind myself not to be afraid of doing or pitching something different. It

NG** continues on **page 13.

*NG continues from **page 14.***

is very easy to stick with a format that you know does well, but I think there are many ways you can tell a story.

Do you have any storytelling tips?

Write scripts with the visuals at the forefront of your mind. When I first started writing scripts, I fell into the trap of writing for text rather than video but soon learned that showing something was much more impactful that just telling something.

Another tip I have is to do your homework. When I'm covering a new science paper, I make sure to find out what has been said about the topic before and how this finding is significant to the science community. I make sure I understand the scientific concepts, which is important since I am the one breaking it down to the public.

What do you enjoy most about working here?

One of the things I love about working here is that everyone is open to collaborating and spreading their knowledge.

If someone has a strong skill in something, I'm able to learn from them. It is great that we can learn from each other to develop individually and as a team.

What do you do for fun?

From high school through university, I was in a contemporary dance company that performed around the United Kingdom. I also like to paint and draw. I try to give paintings as gifts to friends and family.

I recently passed my motorcycle riding test. I'm excited about exploring the world on two wheels and learning how to fix and repair bikes.

I have lived by the coast my whole life and this is where my love of outdoor life has developed.

I'll take any chance to camp, hike, explore and take photos, or be in water whether that is in a lake, ocean or stream.

What is your "six-word memoir?" A six-word memoir describes something in just six words.

Everything's impossible until somebody does it.

EVERYTHING'S IMPOSSIBLE UNTIL SOMEBODY DOES IT.

- JOY NG

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Goddard Space Flight Center
Volume 1, Issue 2 I September 2016

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NASANEXT is a publication of Goddard Space Flight Center's Office of Communications to engage children and young teens in the fascinating world of science and space exploration.

FOR EDUCATORS

Want to incorporate **NASA**NEXT articles into your classroom? Get started with these lesson plans!

Juno's arrival at Jupiter (page 3)
Check out the Juno Toolkit for links to data, videos and activities that will help you and your students explore Juno's role in learning more about Jupiter.
solarsystem.nasa.gov/missions/juno/junotoolkit

Planet orbiting two suns discovered (page 5)
This lesson helps students understand how the Kepler Space Telescope is helping researchers to learn more about planets outside of our solar system.
spacemath.gsfc.nasa.gov/Modules/7Module10.html

Webb sunshield (page 8)
Explore the James Webb Space Telescope educator page for activities and lessons.
jwst.nasa.gov/teachers.html

Have your students check in on what's happening live in Goddard's clean room via the Webb cam.
www.jwst.nasa.gov/webcam.html

There are a lot of activities to observe how heat and the sun can impact materials and to explore ways that our engineers work to protect spacecraft from the sun. The activity looks at how different materials can help to control the speed at which items heat up.
http://www.solarweek.org/cms/LinkClick.aspx?fileticket=3%2fr3WRtEZ84%3d&tabid=166

New Hubble Final Frontier image (page 9)
#spothubble — The Hubble Space Telescope has impacted our lives from science to art to dance. Havey our students make the connection that Hubble and space science isn't just reserved for the classroom by getting them to notice and pay attention to Hubble in their daily lives.
www.nasa.gov/content/goddard/2016/spothubble

Sea ice and high temperatures (pages 10-11)
Use real NASA data to make observations on temperature and sea ice coverage in Alaska.
http://mynasadata.larc.nasa.gov/lesson-plans/?page_id=474?&passid=90

To learn more about NASA's many educator resources, check out NASA's Office of Education website and the Science Mission Directorate's digital collection of Earth and space science resources, NASA Wavelength. You can also receive regular updates on educational resources and activities going on at NASA centers right now by signing up for our weekly email lists, ***EXPRESS and Science WOW!***

QUICK LINKS

NASA Education
www.nasa.gov/offices/education/about

NASA Goddard Office of Education
www.nasa.gov/centers/goddard/education

NASA Wavelength
http://nasawavelength.org/

Digital Learning Network for students/teachers
http://www.nasa.gov/dln